

Tri-tube Freeze-core Procedure for
Sampling Stream Gravels

(U.S.) Corvallis Environmental Research Lab., OK

Oct 81



U.S. Department of Commerce
National Technical Information Service

NTIS

TECHNICAL REPORT DATA (Please read instructions on the reverse before completing)		
1. REPORT NO. EPA-600/J-80-344	2. Journal Article	3. RECIPIE PB82-127515
4. TITLE AND SUBTITLE Tri-tube Freeze-core Procedure for Sampling Stream Gravels	5. REPORT DATE October 1981	6. ON CODE 308086
7. AUTHOR(S) Frederick B. Lotspeich and Barry H. Reid	8. PERFORMING ORGANIZATION REPORT NO.	
9. PERFORMING ORGANIZATION NAME AND ADDRESS Environmental Research Laboratory Office of Research and Development U.S. Environmental Protection Agency Corvallis, Oregon 97333	10. PROGRAM ELEMENT NO.	11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Same	13. TYPE OF REPORT AND PERIOD COVERED	14. SPONSORING AGENCY CODE EPA/600/02
15. SUPPLEMENTARY NOTES Progressive Fish-Culturist, 42(2):96-99 April 1980		
16. ABSTRACT This paper presents a description of equipment and methods for sampling streambed gravels by using a three-tube array of cryogenic samplers and compares the tri-tube freeze-core sampler with single-tube freeze-core samplers. ←		
17. KEY WORDS AND DOCUMENT ANALYSIS		
a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
18. DISTRIBUTION STATEMENT Release to Public	19. SECURITY CLASS (This Report) Unclassified	21. NO. OF PAGES
	20. SECURITY CLASS (This page) Unclassified	22. PRICE

Tri-tube Freeze-core Procedure for Sampling Stream Gravels

Frederick B. Lotspeich and Barry H. Reid

Corvallis Environmental Research Laboratory, U.S. Environmental Protection Agency
200 SW 35th Street, Corvallis, Oregon 97330

ABSTRACT: This paper presents a description of equipment and methods for sampling streambed gravels by using a three-tube array of cryogenic samplers and compares the tri-tube freeze-core sampler with single-tube freeze-core samplers.

Fishery biologists have long known the general properties of spawning gravels used by salmonids, but the lack of a simple, reliable sampling method to measure textural composition of gravels has hindered quantitative description of these important natural elements of lotic habitats. A new method for quantitative sampling of streambed gravel, called the FRI method (Fisheries Research Institute, University of Washington) was developed by McNeil and Ahnell (1960). This sampler consisted basically of a pipe 15 cm in diameter that was inserted vertically into the substrate. Sediments within the pipe were removed by hand and sorted with a series of sieves.

Fairly representative samples of spawning beds could be obtained with this technique. The reliability of the FRI method was a great improvement over that of previous devices, but the method suffered from two major deficiencies: (1) the introduction of personal bias by the operator in removing the sample by hand from the pipe; and (2) the inability to detect stratification of sediments. Both factors can be important when the effects of accelerated sedimentation are studied.

To overcome these problems, investigators have developed several methods of in situ freezing of columnar substrate samples. The most successful is the freeze-core method reported by Walkotten (1976), in which liquid carbon dioxide is used to freeze the gravel to the depth penetrated by a sampling tube. Although this method solves the problem of detecting stratification, inadvertent loss of core boundary particles during extraction could lead to sampling bias, either toward fine particles if too many large ones are lost, or toward large particles if too many fine grains are lost. The tri-tube procedure described here reduces this bias by retaining a representative population sample in the central axial portion of the core volume and by increasing the ratio of sample size to surface as measured by weight.

Description of Tri-tube Components

Several components of this equipment are identical to those described by Walkotten (1976). The CO₂ fire ex-

tinguisher bottles, hoses, manifolds, and tube dimensions are the same. The modifications described here concern the use of three tubes in a triangular configuration (Fig. 1). This multiple-tube array requires additional equipment or substitutions: (1) a manifold at the gas cylinder to distribute CO₂ to each freeze-core tube; (2) a template to align the tubes during placement and freezing; (3) substitution of thin-walled steel tubes for the copper suggested by Walkotten; (4) a treble hook for extracting the core; and (5) elimination of the tee handle and substitution of couplers with short chain loops to engage the treble hook for removal.

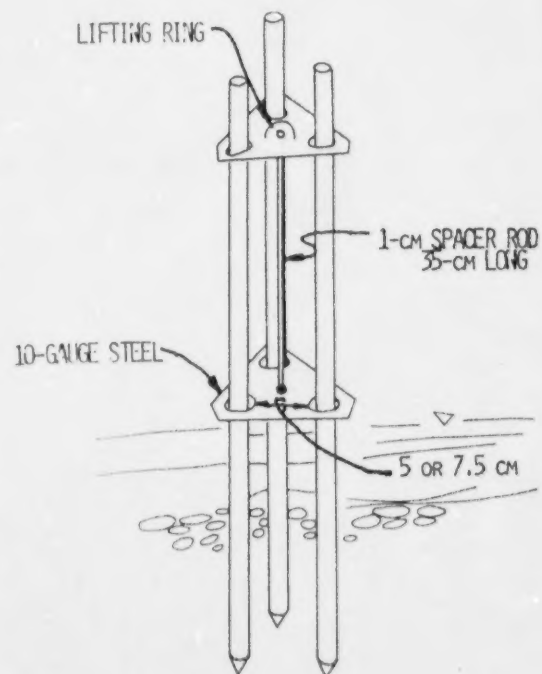


Fig. 1. Diagram of the tri-tube sampler. We used a 35-cm spacer rod, but this dimension is not critical.



To extract tri-tube cores we use a small chain hoist because of the proven reliability of this type of equipment. The legs of our aluminum tripod are 2.1 m (7 ft) long and can be modified for rapid take-down to facilitate transportation.

The three-way manifold has a 0.92- to 0.62-cm (0.375- to 0.25-in.) reducer, but all other screw-on couplers use 0.62-cm pipe threads. A rapid-disconnect fitting for the gas manifold facilitates coupling of the hoses and prevents kinking. The upper and lower plates of the template are held apart by a central rod and act only as spacers (Fig. 1). Spacing between edges of the holes is determined by the texture of the gravel being sampled. For textures with maximum grain size of 100-150 mm, a 7.5-cm (3-in.) spacing between edges of holes is satisfactory; for smaller gravel ranging up to 100 mm, a spacing of 5.0 cm (2 in.) is more desirable. Sediments finer than about 50 mm may be better sampled with a spacing of about 3.7 cm (1.5 in.). We have used only the 5.0- and 7.5-cm spacing. If the spacing is too large for the texture being sampled the material between the three tubes does not freeze and this central core is lost. It is the contents of the central core that increase the volume of gravel per tube being sampled. Figure 2 shows the entire apparatus assembled ready to freeze a core.

Walkotten suggested the use of rigid copper freezing tubes because of their high thermal conductivity. We have observed no apparent difference in the thermodynamic performance of copper, monel metal, stainless steel, and thin-walled steel tubing, but because steel or monel tubing is strong enough to withstand more physical abuse, one of these is preferred. Heat resistance of the tube is negligible compared with that of the frozen gravel with its interstitial water or ice.

Early experimenters with the freeze-core technique assumed that a tube could be manually inserted into stream gravels. Experience has shown that manual insertion is seldom possible, except in sands and fine gravel; the tubes must be driven into coarser substrates. Steel or monel tubing may be driven directly into the gravel without serious deformation. In compact or coarse gravels, a pilot rod is first driven to the depth of the sample to reduce the difficulty of driving the freezing tubes. A temporary brass plug on the top of the freezing tube reduces damage to the tube by absorbing the shock of hammer blows, which is further reduced by using a rawhide-faced 2-kg hammer.

Procedure for Using the Tri-tube Method

An estimate of the proper size of template is made at the sampling site and the first tube is driven to the desired depth, preceded by a pilot rod if needed. The template is then slipped over the tube and the second tube inserted through the holes and driven into the substrate. In coarse substrates it may be necessary to make several attempts to drive the tube by rotating the

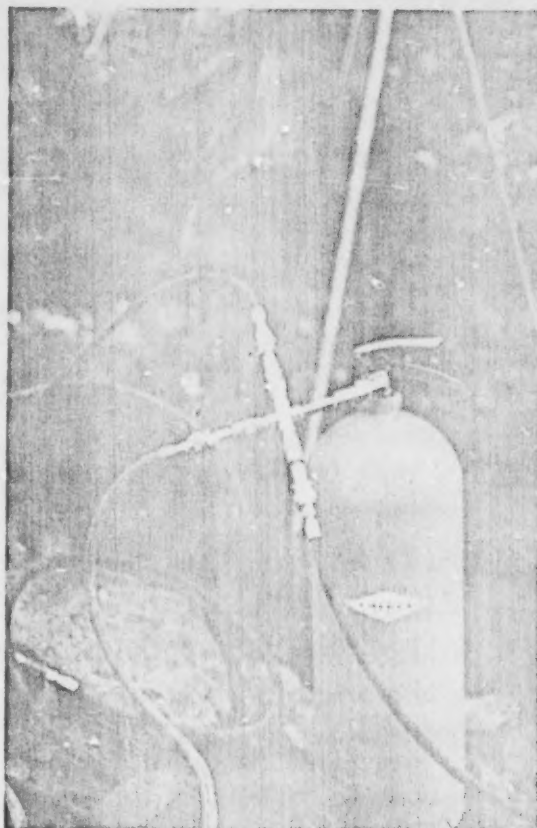


Fig. 2. Three-way manifold between CO₂ bottle and tri-tube sampler (photo by P. Lotspeich).

template around the first tube. The third tube is then inserted into the template and driven into the substrate. In very coarse gravel it may not be possible to drive the third tube through the template as aligned by the first two tubes. In such cases the template may be removed from the two emplaced tubes, rotated 180°, replaced over the tubes, and another attempt made to drive in the third tube. Such a procedure is usually successful in establishing the tubes in the desired array. The tubes may not always be vertical (which is desirable but not necessary), but they should be emplaced and extracted nearly parallel.

Couplers are attached, the treble hook secured to one or two tubes, and the tripod placed over the assembly. The tripod must be placed with care to ensure that the final alignment of the hoist is parallel with the axis of the tubes, which may deviate somewhat from vertical (Fig. 3). The delivery manifold is attached to a CO₂ bottle and the freezing manifolds placed in the freezing tubes. The CO₂ valve is then opened fully and held open until all contents are expended. A 9.1-kg (20-lb) CO₂

bottle will empty through three freezing manifolds in 2.5 to 3 min, which is ample time to obtain a satisfactory sample. During freezing each manifold should be jiggled occasionally to prevent solid CO₂ from building up within the freezing tubes.

Immediately after freezing, the frozen core is removed by the chain hoist. For large samples, considerable force is required to remove a frozen core. Pulling a misaligned core may fracture the sample and part may be lost or the tubes may be bent. As soon as the core is pulled free of the surrounding gravel, the sample is taken to a prepared site and the frozen mass removed by chipping with a hammer. When subsamples are desired to study stratification, they can be chipped away at points where changes occur or the entire mass can be thawed before subsampling.

Comparison of Freeze-core Methods

Our early success with the tri-tube variation indicated that the freeze-core method could provide enough material to be representative of the substrate being sampled. Table 1 compares weight of samples collected with the single and tri-tube samples from several streams in Oregon during the summer of 1978. All the single-tube samples were from streams in the Suislaw National Forest, western Oregon, where basalts and sandstones are the common parent materials. All the tri-tube samples (except that from Crane Creek) were taken from streams draining volcanic terrains. Single-tube samples ranged in weight from 1 to 5.4 kg (average, 2.6 kg). Samples from sandstone terrain were generally smaller than those from basalt areas. The weight of tri-tube samples ranged from 3.0 to 24.4 kg (average, 10.2 kg), about four times that of the single-tube samples. One tri-tube sample weighing 6.5 kg obtained in sandstone substrate (Crane Creek) was about four times the average from the four single-tube samples from the same area. We believe the tri-tube freeze-core provides the most representative substrate sample that can be obtained with sampling equipment now available.

When we compared percentages of sediment passing a 2-mm sieve, we found little difference between the two sampling methods. Sandstone substrates, however, contain a larger fraction of sediments that pass through a 2-mm sieve than do basalts. The one tri-tube sample from Crane Creek contained nearly the same percentage of particles less than 2 mm as the average of the four single-tube samples. On the basis of these comparisons, we conclude that the criticism of the freeze-core method being biased in favor of the larger grains is largely unfounded and that a sample obtained by the tri-tube does, in fact, represent the substrate at that point. The additional feature of being able to detect and measure textural changes with depth should enable fishery biologists to study spawning gravels with confidence that their results will truly represent sediment size dis-

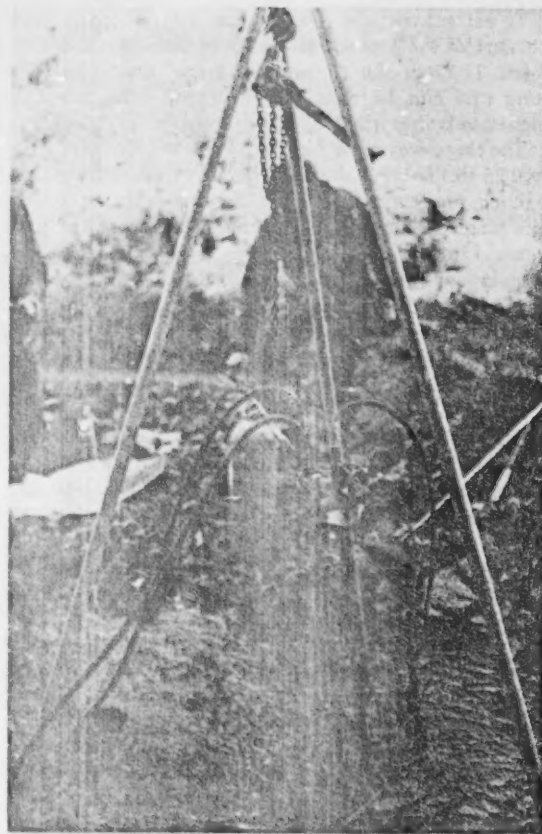


Fig. 3. Angle of sampler in coarse substrates may not be vertical but tubes are parallel. Note that the hoist is positioned to pull parallel to the tubes, not vertical (photo by P. Lotspeich).

tribution at the time of sampling.

Using a tri-tube freeze-core sampler and the modified FRI method, we collected samples at sites as near to one another as possible without causing intersample disturbance (Table 2). Sample weights obtained by tri-tube freezing ranged from 5.5 to 31.3 kg, whereas the range of sample weights obtained by the FRI method was much narrower, from 20.0 to 28.3 kg. These samples were from the Rogue River and Big Butte Creek below Lost Creek Dam where the substrate was coarse. Boulders more than 250 mm in diameter were common and the percentage of fine textured material was low. Although total weight variability for the tri-tube sampler was much higher than for the FRI samples, variability in the percentage passing 2 mm was higher for the FRI sampler.

These results led us to conclude that the tri-tube procedure is a reliable method for sampling stream sediments. It is also more versatile than the FRI sampler since it can be used in fast deep water and under an ice

Table 1. Comparison of single-tube and tri-tube freeze-core gravel samples.

Single tube*		Tri-tube	
Stream and rock Total (kg)	Percent < 2 mm	Stream and rock Total (kg)	Percent < 2 mm
Tep Mile-Basalt		Meadow-Basalt	
2.60	5.0	14.07	5.6
1.82	9.8	12.00	7.4
1.21	8.4	24.40	5.7
1.94	1.0	9.65	12.8
4.25	5.9	11.94	3.5
3.26	7.0	14.88	11.3
Cape-Basalt		Big Butte-Volcanics	
5.39	4.2	11.83	11.0
1.94	13.1	12.60	12.5
1.22	9.7	7.81	3.2
4.08	4.5	Cougar-Basalt	
4.70	4.4	13.52	19.0
2.53	6.5	13.82	6.9
		5.16	12.2
Hadsell-Sandstone		Mill-Basalt	
3.10	9.0	13.46	7.2
3.22	13.4	10.90	3.9
2.04	12.8	11.40	6.7
2.35	16.3	Fawn-Volcanics	
2.81	22.4	2.99	9.4
2.31	26.2	3.99	8.7
3.06	16.0	7.71	7.3
Crane-Sandstone		Crane-Sandstone	
2.76	21.7	6.54	23.7
1.14	27.8	Average	
1.60	20.6	10.22	
1.00	28.6	Average	
Average		2.62	

* These data were furnished by the U.S. Forest Service, Corvallis, Oregon.

Table 2. Comparison of weights of freeze-core gravel samples from the tri-tube and modified FRI samplers, Rogue River, September 1978.

Location	Tri-tube		Modified FRI*	
	Total weight (kg)	Percent < 2 mm	Total weight (kg)	Percent < 2 mm
Hatchery				
A	31.33	6.1	26.96	8.0
B	5.54	11.4	20.34	15.2
C	14.79	5.3	27.08	3.5
Bridge Hole				
A			27.70	0.5
B	10.39	6.2	20.02	1.4
C	8.56	2.8	25.23	8.2
Big Butte Creek				
A	12.60	12.5	23.39	4.5
B	7.81	3.2	25.60	3.5
C	11.83	11.0	28.29	6.3
Average	12.86		24.96	

* These data are from Shirazi (1979).

cover, and samples can be stratified by depth. We recommend that this method be standardized for sampling stream sediments whenever its definite advantages, as outlined, are required.

References

- McNeil, W.J., and W.H. Ahnell. 1960. Measurement of gravel composition of salmon stream beds. Fisheries Research Institute, University of Washington, Seattle. Circ. 120. 12 pp.
- Shirazi, M.A. 1979. Baseline gravel composition below Lost Creek Dam, Rogue River. Spec. Rep. to Oregon Fish Game Dep., Corvallis. 10 pp.
- Walkotten, W.J. 1976. An improved technique for sampling streambed sediments. U.S. Dep. Agric. For. Serv. Res. Note PNW-281. 11 pp.

Accepted 1 November 1979

(a follow-up paper discussing improvements in the equipment, is the following.)

An improved tri-tube cryogenic gravel sampler by Fred H. Everett, Carl E. McLammon, and John F. Vard. Pacific Northwest Forest and Range Experiment Station, Portland OR, PNW Research Note, PNW-350, March 1980. 8p.